REPORT TO THE

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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A Study of Brain Function Through Advanced Computer Techniques for Analysis of Electroencephalographic Data

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Our research under this grant has continued at a very high level in the past six months. The grant itself represents the rental on an SDS 930 computer, currently housed in the Space Biology Laboratory in the Brain Research Institute. Its intended transfer in the immediate future to the new Campus Space Sciences Center will see its full utilization on a series of NASA supported studies, indluding simulations of the NASA 30 day primate biosatellite flight. We also anticipate extensive studies of data from manned flights and baseline data acquired in terrestrial simulation on man.

In the past six months, this computer has been heavily used for completion of analyses of EEG data from fifty astronaut candidates under Contract NAS 9-1970 from the Houston Manned Spacecraft Center. This data has provided the first "library" of normal EEG baseline data from a population of healthy adult males, and the rigid protocol adopted in its acquisition has allowed us to recognize patterns between individuals in the population, which have completely escaped visual interpretation of such complex records in the past.

This study in the normal human EEG has been made the subject of a Final Report on NAS 9-1970 and clearly shows the ability of our spectral analysis techniques to demonstrate sharply differing patterns across a population of individuals in relation to well specified behavioral situations, ranging from complex visual discriminations through states of fatigue and drowsiness to the deepest sleep.

Having identified the patterns, we have proceeded further by the use of pattern recognition techniques in which automated recognition methods have been applied to data from different individuals in a spectrum of behavioral situations. Using this matrix of analysis method, it has been possible to show high accuracy in computed recognition of basic states of consciousness. These first steps in pattern recognition methods augur well for the future of such techniques in their application to aerospace flights.

Other studies have been concerned with the mathematical models of the behavior of neuronal populations, in the contributions of individual neurons to the gross wave process recorded in the EEG. Initial computer analyses by spectral techniques with calculation of coherence functions, had indicated that the intracellular waves recorded by the most exacting electrophysiological techniques have similar spectral density distributions to the EEG recorded gorssly in the same domain of tissue. We have extended these studies in recent months to an examination of the amplitude distributions in intracellular records of waves in unanesthetized cortical neurons of animals, and, at the same time, have examined the amplitude distributions in the gross EEG process. By examining the trend towards or away from a Gaussian distribution, it has been possible to provide an evaluation of the degree of "cooperativeness" in a population of neuronal generators, and to show that there are differences in this regard between normal and abnormal brain tissue. For example, whereas the gross EEG in normal brain tissue regularly converges towards a Gaussian amplitude distribution, the intracellular waves rarely show such a Guassian distribution for any significant period, except in deep sleep. In the gross EEG, the sudden imposition of a mental task in a resting individual will cause increasing divergence from Gaussian distributions. The findings in epileptic brain tissue of man have indicated distributions suggestive of greater degrees of connectivity than those in normal tissue.

Arising from these studies in men and animals, we have developed certain models of the distribution of generator functions in cerebral cortex. These appear to be amongst the first realistic models of the organization of such functions within a particular domain of brain tissue, and at a higher integrative level in complex brain systems linking one region with another.

In addition to these contributions in fundamental and applied physiology, the SDS 930 system has become part of a time-shared console operation, in which macro- and micro-command functions can be exercised over this computer through remote consoles in the investigator's laboratory. This aspect of a time-shared computer operation for physiological data analysis represents an extension of the state of the art in the handling of massive amounts of data at high speeds, with data transfer rates up to 500,000 bits per second. Shortly, we anticipate a direct interface between the SDS 930 system and the 360-75 system currently installed in Health Sciences Computer Facility.

It should be emphasized that utilization of this computer under NASA support has provided us with the means of development of input and output systems including special display devices that are especially suited for the needs of the physiological investigator. In addition, it has given us a grasp on the problems that confront the development of specialized flight monitoring computers, capable of early recognizion of undesirable trends in states of alertness, and the appearance of fatigue and inattentive behavior.

No description of our NASA supported system would be complete without full acknowledgement of the contribution made by the UCLA Health Sciences Computing Facility in the performance of the bulk of the extensive time series analyses that are the core of our computer methods. At this time, we consider many advances that we have made in the application of spectral analysis methods to physiological data are due to the joint utilization of the NASA supported SDS 930 and the Health Sciences Computer Facility. Both represent unique and separate facets of a complex combined operation. Without the multiplexing, analog-digital conversion and time-shared modes of operation available in the 930, no possibility would have existed for preparation of such large amounts of data for computational analysis. In the same way, the display methods now available on the SDS 930 system are uniquely valuable to the physiologist in comprehending complex computer outputs. Yet at the same time, it must be recognized that the SDS 930 computer alone could never have accomplished more than a tiny fraction of the complex analyses that have gone into the recognition of fundamental cellular functions, the development of baseline and pattern recognition techniques for the human scalp EEG, and in particular, in the analysis of the flight data from the Gemini GT-7 flight.

It would be hoped that in the light of extensive and seemingly successful utilization of this NASA supported facility, means might be found for continuing NASA support of such a vitally needed instrument.

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